VEGETATIONAL SURVEY OF THE LOWER RIO GRANDE VALLEY, TEXAS[1]

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Botanical Exploration

Southern Texas has been known to botanists since 1826. The earliest botanist was the Swiss, Dr. Luis Berlandier (4). He was sent as naturalist of the Mier Terán Expedition or Comisión de Límites by the Mexican Government to determine the character of the country along the proposed United States and Mexican boundary in 1828. Thomas Drummond, upon seeing a set of Berlandier's collections, was impressed by the vegetation of the region and while on a collecting tour to America went to Texas in 1833–1834 and spent some time collecting in the vicinity of Galveston Island (38). W. J. Hooker (26) published notes on this expedition.

Ferdinand Lindheimer began collecting in Texas in 1836 but because of conditions in the early days of the Republic did no extensive work until 1842. Dr. George Engelmann, a friend and German schoolmate of Lindheimer, suggested to Asa Gray that they take the burden of classification and distribution off his hands, permitting him to devote his entire time to field work. Lindheimer contributed much to the botanical knowledge of the state and well deserves the title "Father of Texas Botany." His plants were described by Gray and Engelmann (18, 22).

In 1854 the work of making a United States-Mexican Boundary Survey was begun. Major William H. Emory (17) was placed in charge of this project. Vegetational and geological reports of this survey by Dr. C. C. Parry and Assistant Arthur Schott give interesting information on the Lower Rio Grande region. Charles Wright, who, in connection with the movement of troops to western forts, had made his first collections of plants in Texas in 1847 to 1848, was in 1851 sent as botanist and surveyor on the United States-Mexican Boundary Survey Commission from the Rio Grande to the Pacific, under Emory. Collections of plants (exclusive of the Cactaceae) made during this survey were determined and distributed by John Torrey (34). George Engelmann (19) determined the Cactaceae.

John M. Coulter (13) published on the plants of an expedition to the region of the Rio Grande made in 1887: "Mr. G. C. Nealley was engaged by the Division of Botany (U. S. Department of Agriculture) to make collections of plants during 1887, 1888, and 1889 in the more unexplored parts of Texas, chiefly in

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the counties bordering the Rio Grande. It was hoped that many of the rarer plants of the Mexican Boundary Survey and the early collections would be rediscovered, that additional Mexican types would be found to be members of our flora, and that species new to science would be brought to light." A large and valuable collection was made on this expedition.

Valéry Havard (25) made extensive collections along the valley of the Rio Grande and in the adjacent territory. His report on this work really marks an important step in Texas botany from pure description to a study of plants in relation to their environment, ecology, and pathology. An account of Havard's work is given by Winkler (38).

C. Hart Merriam (28) in his much discussed "Life Zones and Crop Zones of the United States," by mapping the Brownsville region as "Tropical" called attention of botanists to the special interest that the region might hold for them. Cultivated as well as wild plants of the Rio Grande Valley are listed in the paper.

In an account of changes of vegetation in the south Texas prairies, O. F. Cook (11) concluded that elimination of prairie fires as a result of intensive grazing is the principal cause of the spread of chaparral vegetation over much of the coastal prairie.

Dr. J. N. Rose made investigations in the Lower Rio Grande Valley in connection with his studies in the family Cactaceae. The great monograph of this family by Britton and Rose (7) incorporates many notes and photographs by Robert Runyon of Brownsville, an amateur botanist who has contributed valuable notes on distribution as well as on new species. He was co-author of "Texas Cacti" (30) and published also an article in *Desert,* May, 1936, on "Cacti of the Lower Rio Grande Valley." Another student of the flora of this region is Father Chateau of Mission, Texas.

In this brief summary many collectors and authors who have contributed to the knowledge of the botany of the Lower Rio Grande have had to be neglected. However, the reader who has a particular interest in the region may turn to Charles H. Winkler's account (38) of botanical investigations in Texas. He includes an annotated list of 121 publications.

Climate

The temperature variation in this region is not great. At Fort Ringgold it averages by months from 57.7° F. in January to 88.7° F. in July; and at Brownsville, from 59.1° F. in January to 83.7° F. in August. These figures were compiled from statistics of the U. S. Weather Bureau over a period of about forty-seven years (35). Killing frosts are rare, but frequent enough to make the commercial growing of bananas and other tropical fruits impossible.

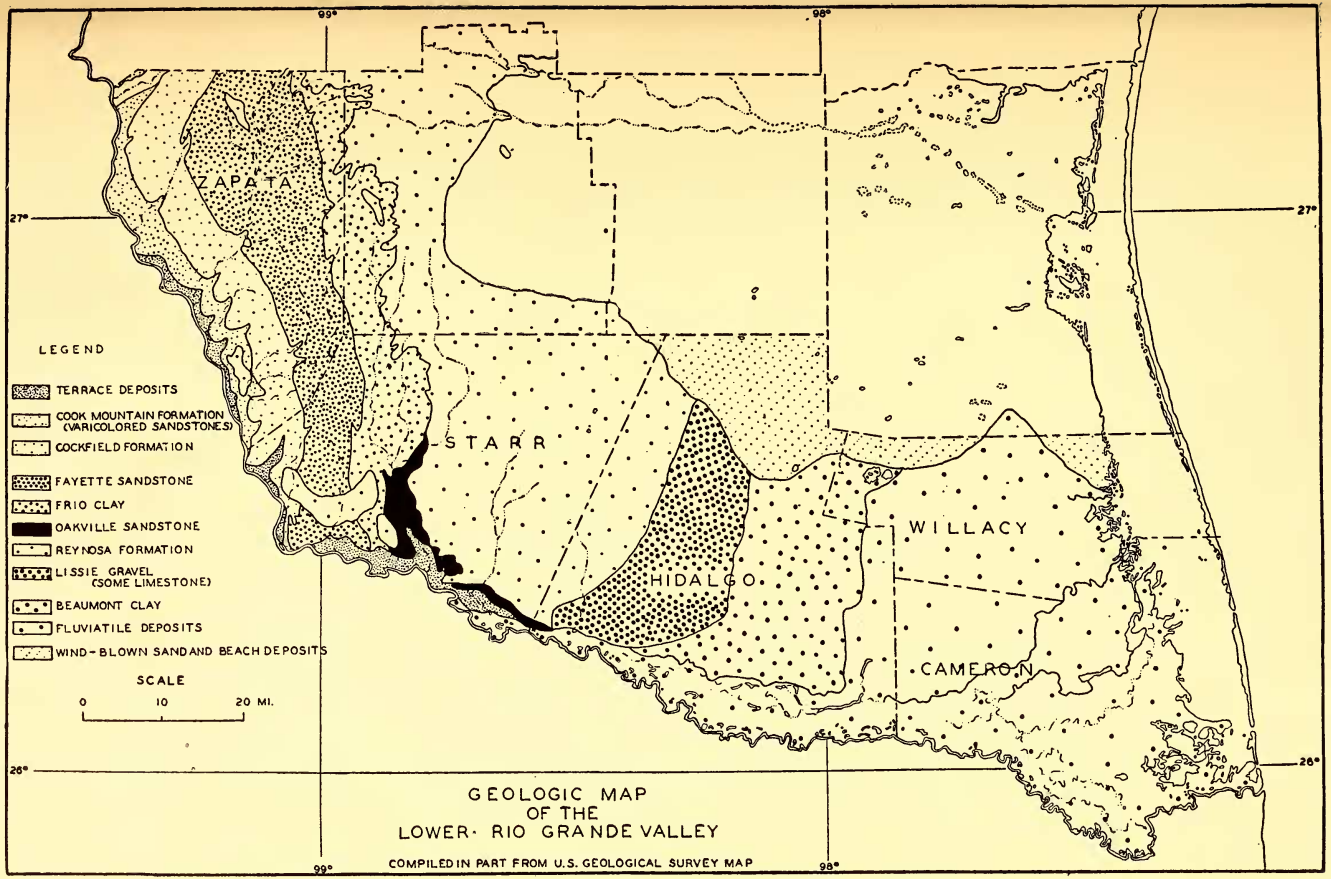

FIG. 1. Geologic Map of the Lower Rio Grande Valley.

Average monthly rainfall at Fort Ringgold varies from 0.29 inches in February to 3.13 inches in September, with a total of 17.46 inches annually; at Brownsville, from 1.27 inches in March to 5.62 inches in September, with a total of 26.89 inches annually. This record was made over a period of thirty-nine years at Brownsville and thirty-seven years at Fort Ringgold (35).

The weather is usually clear with a brilliant sun; but in June and September there are such violent thunder storms that the usually dry, deep arroyos in Starr and Zapata counties become impassable torrents. The prevailing wind in the Lower Rio Grande Valley is from the southeast. It blows almost steadily in the summer but decreases during the winter. It is of the monsoon type. "Northers" occur with varying frequency from late October until March, causing a very sharp drop in temperature within a short space of time. They are called "dry" or "wet" northers, depending upon whether or not the wind is accompanied by precipitation. Since rainfall in this region is so irregular, farming as a rule is very uncertain in unirrigated sections. However, cotton raised by dry farming methods seems to be quite successful because the plants are less injured by the boll-weevil and the cotton root rot fungus (*Phymototrichum omnivorum*) than if grown under moist conditions.

Topographic Features

Beginning at sea-level in the low grassland and swampy areas of the coast, the Rio Grande Plain on the average rises at the rate of approximately five feet per mile. The coast is protected by Padre Island, a very narrow strip composed mostly of dune sand, extending along the coast from the mouth of the Rio Grande to Corpus Christi, and separated from the mainland by Laguna Madre, which is four to ten miles wide and rather shallow. In general the coastal area consists of beach with low dunes, beyond which are barren salt flats and salt marshes. On the surface of the delta there are numerous low mounds locally known as "clay dunes" (21). In northern Willacy County the wind piles up true dunes (some of them twenty-five feet high) and blows out depressions, making the topography irregular. All of Cameron, most of Willacy, and a small portion of Hidalgo counties are included in the Rio Grande delta.

The greater part of Hidalgo and Starr counties is included in the Hebbronville Plain. There is a low rise which includes the towns of Mission, McAllen, San Juan, Pharr, and Donna, and a limited area near Raymondsville. This is known as the Mission Ridge. All of the Rio Grande Delta with the exception of this ridge has been subject to flood in the past. The delta begins at Peñitas, and in ordinary floods the water breaks out here, covering the streets of the village and filling in all of the low places south of the Mission Ridge. Most of the sand belt occurs north

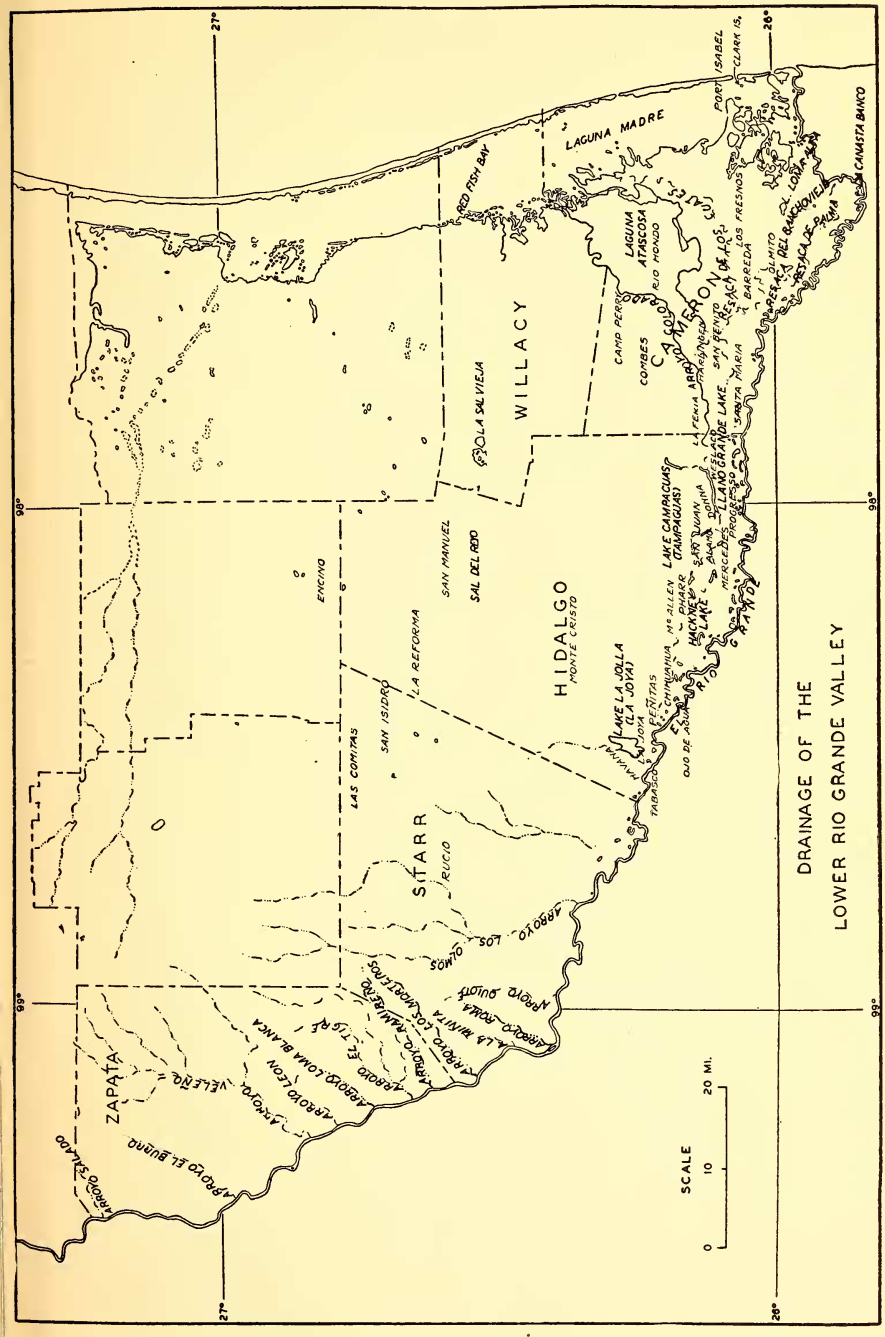

Fig. 2. Drainage of the Lower Rio Grande Valley.

of the Lower Rio Grande area, but the southern end extends into northern Hidalgo County and covers a small corner of Starr and a portion of Willacy County (text fig. 1). The bed rock of this region is covered by wind-blown sand. There are some migrating dunes; others have been stabilized by growth of grass or shrubs.

The Hebbronville Plain extends from the sand belt and the Rio Grande Delta west and north to a rather spectacular topographic feature known as the Bordas Scarp. The west face of this escarpment averages sixty or seventy feet in height and is composed of Oakville Sandstone and Frio Clay (text fig. 1). The absence of erosion on the east side is probably accounted for by the type of soil, which is a porous *caliche* overlain with loose sand (35). The water leaches through so rapidly that little or no erosion takes place. Looking at the Bordas Scarp from the west, it is not unlike some of the flat-topped buttes of New Mexico. More than half of Zapata County is included in the Aguilares Plain (35), which is sixty or seventy feet lower than the west side of the Hebbronville Plain and largely covered with grass and mesquite.

The erosional valley of the Rio Grande begins at Peñitas and extends through Zapata County. Numerous arroyos drain this part of the area, and the rough, broken region where they join the river is known as the "Breaks of the Rio Grande." This belt varies in width from one to fifteen miles, averaging about seven. In a portion of its course the river lies on an older valley filled with detritus in which terraces have been cut. At other points, particularly near Zapata and San Ignacio, the river runs along high cliffs and bluffs of the Reynosa formation.

La Sal Vieja and Sal del Rey (text fig. 2) are salt lagoons. It is thought (35) that the salt has been blown inland from the Gulf.

Geology

The oldest formations are the Cook Mountain and the Cockfield formations (35). They belong to the Claibourne group in the Eocene and extend beyond the limits of Zapata County to the north. The Fayette Sandstone, probably Oligocene, outcrops in western Starr County and covers about one-half of Zapata County, conforming somewhat in extent to the Aguilares Plain. A rather narrow, irregular area of Frio Clay, with an outcropping of Oakville Sandstone near Rio Grande City, overlies the Reynosa formation forming the Bordas Scarp. The Oakville belongs to the Miocene, and the Frio Clay is probably Oligocene.

The Reynosa formation covers the greater part of Starr County and extends along western Hidalgo County. There are small outcroppings elsewhere (text fig. 1). This formation comprises a greater part of the Hebbronville Plain. The Reynosa is probably Pliocene and is composed of an indurated gravel

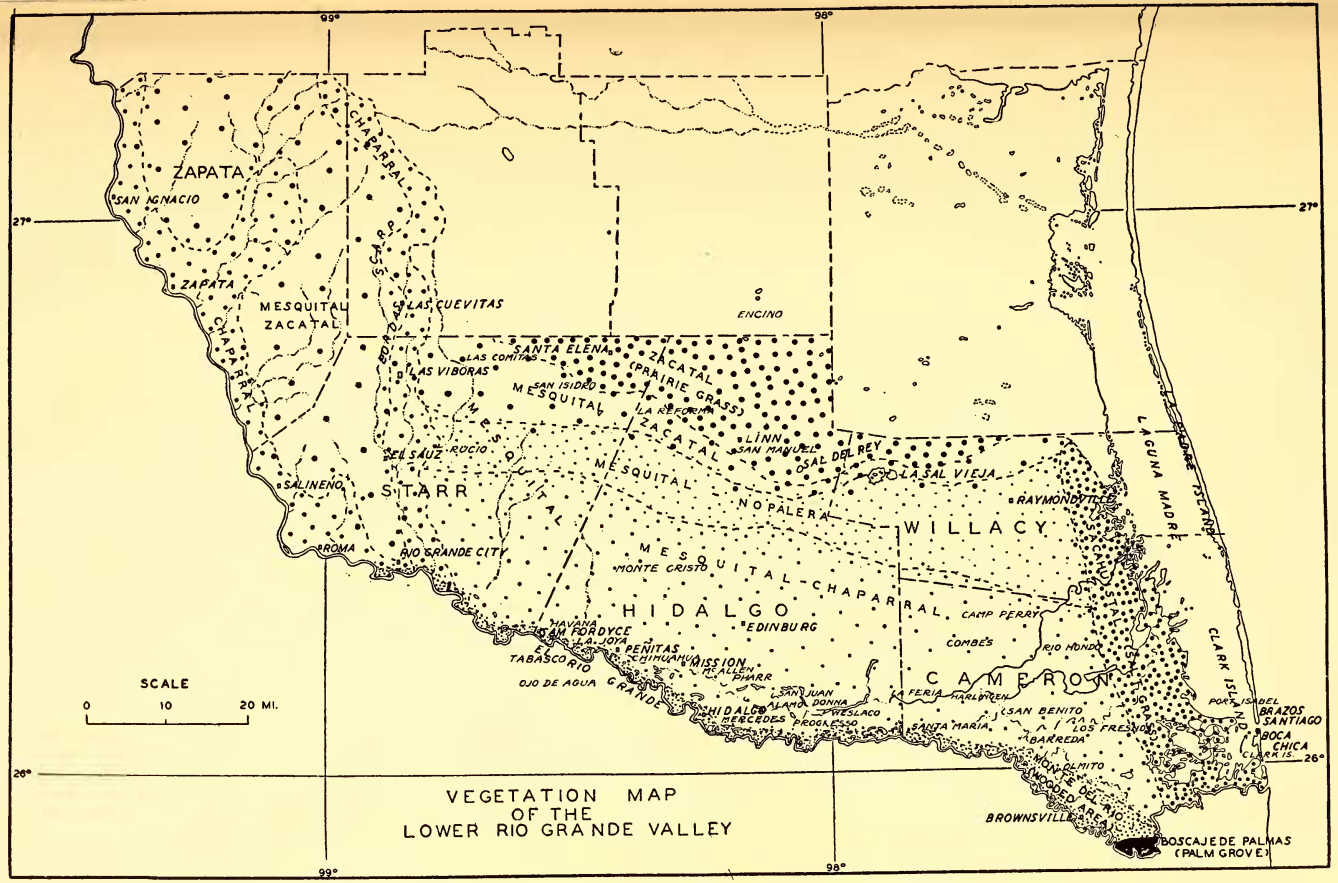

FIG. 3. Vegetation Map of the Lower Rio Grande Valley.

cemented by limestone, limestone with embedded pebbles, sand, gravel, and sandstone. Lissie gravel occupies the central part of Hidalgo County. It is of Pleistocene age and is composed chiefly of unconsolidated gravel, balls of clay or irregular masses, lenses and beds of sand and thin beds of limestone. Gravel from pits near Sam Fordyce and Havana has been used for road-making throughout the Valley.

The area of wind-blown sand and beach deposits is a wide stretch reaching beyond Falfurrias and appearing in the Lower Rio Grande Valley. The Prairie-Grass region and this area almost coincide. Beaumont Clay of the Pleistocene begins at Peñitas, lying east of the Lissie Gravel region and joining the fluviatile deposits which have their origin near Rio Grande City as a narrow strip along the river. These deposits widen out to many miles toward the coast.

Drainage

With the exception of the Arroyo Colorado, the Rio Grande is the only permanent stream. The upper part of the Lower Rio Grande Valley is drained by arroyos (text fig. 2), in which there are streams only following infrequent downpours, the deep, ragged cuts testifying to the force of the torrents. Since these arroyos are not bridged, traffic is sometimes forced to wait for hours for the water to go down.

The poor drainage near the coast has been improved within recent years by the construction of large, open drainage ditches. Poor drainage has been a problem of great concern because much of the irrigated land with insufficient drainage became so impregnated with alkali salts that some crops could no longer be grown. New flood channels and levees, better canal systems and more efficient handling of irrigation water have improved this condition appreciably.

The Arroyo Colorado, a distributary of the Rio Grande, is a deeply cut flood channel starting near Mercedes in eastern Hidalgo County, and continuing in a northeasterly direction through Cameron County to Laguna Madre. The water is salty as far inland as Harlingen because the bottom of the channel is below sea-level and there is little flow (3). Nearly all of the run-off water of Cameron County flows into the estuaries of Laguna Madre.

In part of Zapata County there is no valley on the Texas side of the Rio Grande, the river flowing against high cliffs (pl. IX). In western Hidalgo County the valley has attained the width of perhaps a mile. Lower down it becomes eight miles wide. In western Cameron County the delta is many miles wide, and excess water moves in poorly defined channels across the almost flat surface toward the coastal lowlands. Some of these are *resacas* and *esteros,* low places formed by the old river channels.

The writer's survey of the vegetation of the Lower Rio Grande Valley is based upon field studies made at three different periods and extending over most of the four seasons. The periods of study were as follows: June 30, 1932, to September 15, 1932; February 25, 1932, to July 8, 1933; November 30, 1933, to February 18, 1934. Information necessary for making a vegetational map was obtained by traverses on roads and trails. In general, the roads are fairly good, but some transportation difficulties were encountered, especially in Zapata County. The seasons of the study happened to be very dry; consequently, many herbaceous plants which normally occur during favorable seasons were missing. It was found that in this area vegetation is influenced markedly by edaphic factors, and that it conforms, more or less, to geological formations (text figs. 1, 3).

Local Ecological Nomenclature

The Spanish-speaking people of Mexican stock in southern Texas have developed a very definite and satisfactory classification of the vegetation. Professor Bartlett (ms.) introduced local nomenclature into the description of vegetational types in his account of the botany of the San Carlos Mountains of Tamaulipas. He (2) and Lundell (27) have adopted this system in a phytogeographical study of the Yucatan Peninsula. In the present article local Spanish nomenclature is used to designate phytogeographic divisions, associations, and societies within the association. The writer has spent many years along the Rio Grande and has learned these names directly from Texans and Mexicans.

Frequently the association or society is named for the dominant species. For instance, *mesquital* applies to the association dominated by the mesquite (*Prosopis juliflora* var. *glandulosa*).[2] A society within this association in which the mesquite is dominant is also called *mesquital*. *Zacatal* derived from *zacate* ("grass") designates the grassland association. This name is used particularly for prairie grass. The grassland area is known as *los llanos*. The coastal marsh grass (*Spartina Spartinae*) is known as *sacahuista*, so the community which this species dominates is a *sacahuistal*, and the area is called *llano salitroso*. That part of the salt marsh occupied by water, and in which aquatic plants occur is designated as *badilla salitrosa*, and sometimes as *pantaño*. A *charco* is a depression or low place which supports a growth of cat-tails (*Typha latifolia*), charas, sedges, and other aquatics; while the *resaca* is a larger, more permanent body of water formed by the old river channel. The borders of the *resacas* are sometimes dominated by *Parkinsonia aculeata* (*retama*), and the plant group is called a *retamal*. Other *resaca* communities

[2] Since a systematic list of the species referred to forms a part of this paper, space is saved in the ecological discussion by omitting the authorities for scientific names.

are named *huisachal* for *Acacia Farnesiana* (*huisache*); or *mimosal* for *Mimosa strigillosa*. One *resaca* in Cameron County near Rio Hondo has *Ipomea fistulosa* (*amor*) growing abundantly with both *Parkinsonia aculeata* and *Acacia Farnesiana*. This is a rather unusual situation, since *Ipomea fistulosa* is an escape and even though the species is equalled in dominance by the other two, the plant group receives the name *amoral*.

Hilly territory, chiefly the Bordas Scarp region, is known as *lomeria;* and the high dry land in the upper counties and away from the river is the *mesa*. The *lomeria* and parts of the *mesa* have a characteristic growth consisting mostly of spiny shrubs and stunted trees including many species. The Mexicans call this growth *chaparral,* named from *Acacia amentacea* or *chaparro prieto* (black chaparral) which is usually an important part of the vegetation. A small area, usually a limestone or gravel hill, dominated by this species is also a *chaparral*.

This use of the term chaparral differs from that of Cooper (12) who refers to broad-sclerophyll scrub. He explains that the word "chaparral" is of Spanish origin meaning oak scrub. In California and parts of Mexico this is generally true, but it is not in south Texas. *Chaparro prieto* or black *chaparral* is the Spanish name for *Acacia amentacea,* and any phytogeographic division large or small which this species dominates is referred to as *chaparral*. This term is also used to designate an area covered by a scrubby growth in which the mesquite is inconspicuous or absent. Authors usually include the mesquite in a *chaparral* especially in localities in which the species is stunted and scrubby. Since this paper is following the local Spanish nomenclature for these ecological areas it is necessary to exclude the mesquite. The author feels justified in using the name *chaparral* for the semi-desert brush in view of the fact that it has been used in this sense by several ecologists and other botanists for many years. Emory (17) refers to the vegetation along the Rio Grande as *chaparral*. Warming (36), Drude (16), Bray (5), Engler (20), Harshberger (23), and Tharp (33), are other authors giving this interpretation to the word.

Palma is the Spanish name for palm, and the palm grove or small forest formation near Brownsville is known as *boscaje de palma*.

In general the suffix *-al,* added to the Spanish name of the plant in dominance (sometimes with vowel elision) designates the plant group. An exception to this is *nopalera,* the name used for an association and also for a society of Opuntia (*nopal*).

Such nomenclature as described will have no value in regions where the Spanish language is not spoken; but in Spanish-speaking localities an acquaintance with this method is important. Bartlett (2) considers that much of this folk knowledge can be systematically formulated in an ecological study. It is

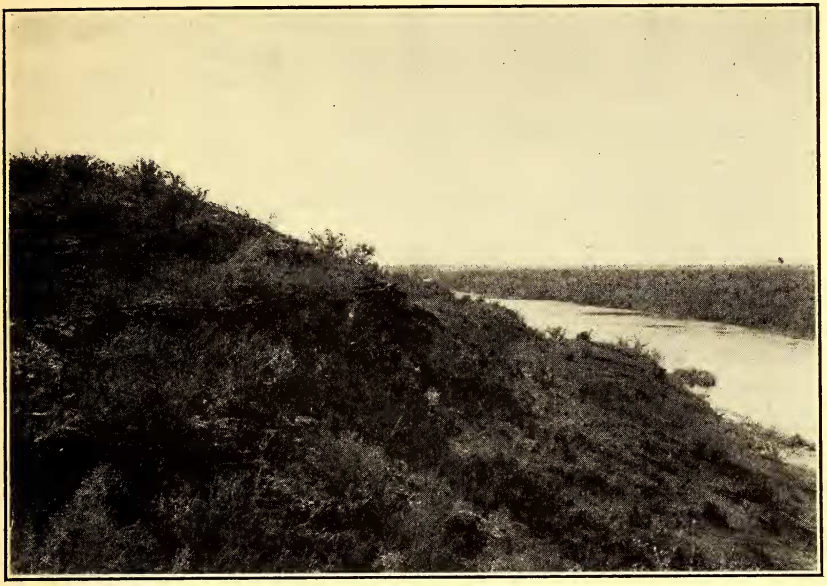

FIGURE 1

FIGURE 2

PLATE IX. Fig. 1. Near San Ignacio in Zapata County the Rio Grande flows along steep bluffs. This hilly area broken by arroyos is known as the "Breaks of the Rio Grande." Fig. 2. *Yucca tenuistyla* (in the foreground) growing in open brush-land. This plant is abundant in the vicinity of San Ignacio.

my purpose to use it in connection with terms ordinarily applied to vegetational groups.

The writer is intentionally avoiding the use of many ecological terms in English since they are often confusing even when not accompanied by a local terminology. The *association* is used in this paper to designate the larger, distinct plant groups, and *society* for smaller groups within the association. The word *community* is used for groups in which the rank is uncertain (37).

Phytogeograpic Study

There is no true tropical area in Texas. The freezing temperatures which sometimes occur limit genuine tropical life to a few insects, reptiles, and birds (1). However, near the mouth of the Rio Grande and extending inland some distance are a few plants of generally tropical distribution. One would place *Sabal texana* foremost in this list. Others are *Daubentonia longifolia, Lantana horrida, Malphigia glabra, Amyris parvifolia, Helietta parvifolia, Schaefferia cuneifolia, Serjania incisa, Cardiospermum Halicacabum, Ruellia tuberculosa,* and *Avicennia nitida.*

The Rio Grande Valley is of much interest botanically because plants representing western desert, northern, coastal, and tropical floras are all found in a relatively small area.

I. The Mesquital Climax

Prosopis juliflora var. *glandulosa* is classed as a *chaparral* plant in parts of the United States where it is shrubby. In the Rio Grande Valley it often reaches a height of thirty-five feet and is sometimes two feet or more in diameter. Here the mesquite is a tree, and any association or plant group in which the mesquite is dominant or especially conspicuous is known as *mesquital.* The *mesquital* covers most of the area and exhibits several phases (text fig. 3).

Mesquital-zacatal. This phase covers the greater part of Zapata County, conforming rather closely to the area known as the Aguilares Plain. It is interrupted by the Bordas Scarp, but continues on the other side as a narrow strip through the northern part of Starr County and across Cameron County to the Gulf.

Most of this territory is a flat sandy plain. Even though the area west of the Bordas Scarp has the same dominating ecological characters as that on the east side, the composition of the vegetation is quite different. The dominants in this western part in Zapata County are: *Prosopis juliflora* var. *glandulosa,* with *Bouteloua barbata* and *Aristida purpurea* probably dominant among the grasses, although it is difficult to name dominants where overgrazing interferes. Other grasses enter this phase of the *mesquital* and there are many societies of mixed shrubs occurring with varying dominance. The most important dominants are:

Zizyphus obtusifolia, Leucophyllum frutescens, Acacia Berlandieri, Bumelia lycioides, Celtis pallida, Schaefferia cuneifolia, Forestiera angustifolia, Acacia amentacea, and *Cercidium texanum.* These shrubs are often scattered through the open mesquite woods and occasionally form a heavy growth near an arroyo.

Yucca tenuistyla is rather abundant northeast of San Ignacio forming societies in open grassy areas. Such a society is known as an *aguapal.* This species is often found in open brushland (pl. IX).

Herbaceous plants form many of the societies. The most important of these are: *Gaillardia pulchella, Lupinus texensis, Oenothera laciniata* var. *mexicana, Parthenium Hysterophorus, Verbesina encelioides, Aphanostephus skirrobasis* var. *Hallii,* and *Jatropha spathulata.*

By far the greatest portion of the *mesquital-zacatal* lies east of the Bordas Scarp. The dominants here are: *Prosopis juliflora* var. *glandulosa* and probably *Aristida purpurea, Eragrostis curtipedicellata,* and *Eragrostis secundiflora.* It is difficult to name a single grass which dominates the entire phase, for there is varying dominance depending upon edaphic factors and light conditions. In poorer soil the grama grasses (*Bouteloua*) grow with little competition; in other situations they form the layer under taller grasses such as *Eragrostis curtipedicellata, Eragrostis secundiflora, Chloris cucullata,* and *Aristida purpurea.*

Other herbaceous plants forming societies are: *Callirrhoë digitata, Commelina crispa,* and *Jatropha stimulosa.* Shrubs invading this phase are: *Celtis pallida, Zizyphus obtusifolia, Leucophyllum frutescens, Acacia amentacea.* Societies and clans of *Opuntia Lindheimeri* and *Opuntia leptocaulis* are occasionally found.

Echinocereus angusticeps, recently described (10) as a species distinct from *E. papillosus,* occurs near Linn, and is found nowhere except in this limited area. It would be interesting to know the conditions which make this locality especially favorable for the growth of this species. The only other cacti found here are: *Dolicothele sphaerica, Neomammillaria hemisphaerica, Opuntia Lindheimeri,* and *O. leptocaulis.* Plants other than cacti are: *Convolvulus incanus, Jatropha spathulata, Prosopis juliflora* var. *glandulosa, Zizyphus obtusifolia, Celtis pallida, Aristida purpurea,* and *Bouteloua barbata.*

The mesquite trees are often infested with mistletoe, *Phoradendron flavescens.* In the region of Zapata and San Ignacio many of them have been seriously damaged by this parasite (6). Around Aguilares the infestation is particularly heavy, and many trees are dying.

Mesquital-nopalera. It is impossible to draw a definite line between the phases of the *mesquital* area. An attempt has been made (text fig. 3) to show the merging of one phase into the other. There is a narrow strip from east to west in which conditions seem optimum for the growth of opuntias. They vie with

mesquite for dominance, and, in some places, crowd out most other species. *Celtis pallida, Viguiera stenoloba, Lippia ligustrina, Lantana horrida,* and *Bouteloua barbata* are commonly found even in the densest growths. Cleared land which has been abandoned is soon covered by a heavy growth of *Opuntia.* The opuntias readily reproduce vegetatively, a single joint being capable of giving rise to one or more new plants. Since these joints are rather easily broken from the parent plants the spread of the genus in a free area is extremely rapid. The soil is a deep sandy loam. There is a gentle slope to the east, providing good drainage, and here the mesquite is probably more abundant than in any other part of the Rio Grande Valley.

Included in the *mesquital-nopalera* there are two depressions known as Sal del Rey (Hidalgo County) and La Sal Vieja (Willacy County). The sparse vegetation at the margin of the lake is of the beach and coastal prairie type. *Monanthochloë littoralis, Strombocarpa cinerescens,* and *Chenopodium album* are most abundant.

Mesquital-chaparral. The invasion of the chaparral vegetation is comparatively recent and thought to be the result of overgrazing and drought. The *mesquital-chaparral* is by far the most important phase of the *mesquital.* It covers the greater part of the territory in the Lower Rio Grande Valley, and in general typifies the vegetation which is found in much of southwestern Texas.

There is a marked variation in soil conditions here, and this difference affects the size and luxuriance of the growth. Many species occur throughout the range, and others are limited in extent.

On the surface of the delta in eastern Cameron County there are numerous small mounds locally known as "clay dunes." They project several feet above the coastal plain and are often covered with a dense growth of chaparral and mesquite (pl. X). This growth is similar in structure to much of the vegetation between Brownsville and San Benito, but the shrubs near the coast are characteristically twisted as a result of heavy winds. The association has no general dominant. Some definite societies within it are dominated respectively by the following species: *Siderocarpos flexicaulis, Leucophyllum frutescens, Zizyphus obtusifolia, Castela Nicholsonii, Randia aculeata, Forestiera angustifolia, Prosopis juliflora* var. *glandulosa,* and *Celtis pallida.* A high ridge near the Rio Grande supports a much sparser growth of shrubs interspersed with mesquite and the following cacti: *Ferocactus hamatacanthus, Echinocereus pentalophus, Ancistrocactus Scheeri, Hamatocactus setispinus,* and *Neomammillaria hemisphaerica.*

These "islands" of chaparral are separated from the main *chaparral-mesquital* area by the *sacahuistal* and a transition zone. There is at first an invasion of mesquite into the coastal prairie area. *Lycium carolinianum, Celtis pallida,* and *Zizyphus obtusifolia* are usually the first shrubs to enter. The composition of the

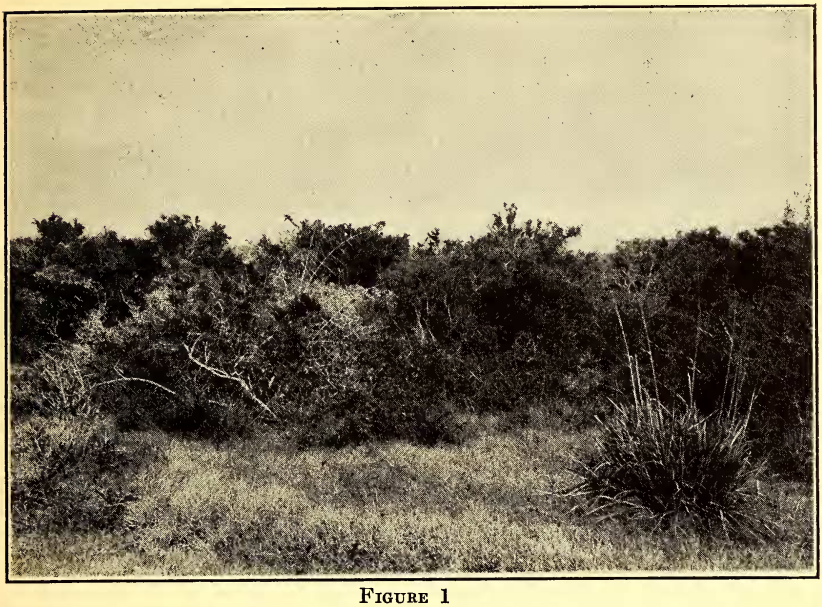

FIGURE 1

FIGURE 2

PLATE X. Fig. 1. Chaparral vegetation covering a "clay dune" near the coast. The dominant shrub with dark foliage is *Siderocarpos flexicaulis.* (See also Pl. XIII, fig. 2.) Fig. 2. The *chaparral-cenizal* near Roma, Starr County. The light areas are dominated by *Leucophyllum frutescens;* the dark areas are dominated by *Acacia amentacea.*

mesquital-chaparral farther inland is similar in parts of Hidalgo and Willacy counties and in Cameron County. The brush is usually five to eight feet tall and rather dense. Dominance is dependent on several conditions, and is difficult to determine in much of this area. The flora is more or less characteristic throughout, but it is varied in its distribution and aspects by several factors.

Soil and drainage have a decided effect upon the distribution of plants in this association.

Limestone outcrops occur as hills surrounded by the Reynosa formation. *Leucophyllum frutescens* and *Acacia amentacea* are dominant on these hills in a society known as *chaparral-cenizal* (pl. X). Other prominent plants are *Bouteloua trifida, Panicum Hallii, Jatropha spathulata, Prosopis juliflora* var. *glandulosa, Karwinskia Humboldtiana, Hamatocactus setispinus, Neomammillaria hemisphaerica,* and *Opuntia Lindheimeri.*

Three species, *Leucophyllum frutescens, Acacia amentacea,* and *Acacia Berlandieri* share dominance on limestone and Reynosa gravel near the Rucio ranch, northeast of Rio Grande City. Other plants occurring in abundance are *Aristida purpurea, Bouteloua barbata, Condalia obovata, Karwinskia Humboldtiana, Bumelia angustifolia, Echinocereus papillosus, Opuntia Lindheimeri,* and *Aphanostephus skirrobasis* var. *Hallii.*

Mortonia Greggii (pl. XI) is dominant in societies on hillsides in a limited area five miles north of La Joya. A few plants are also found near Lake La Joya. The outcrop in the La Joya vicinity is Lissie Gravel. A few stunted plants of the above named species also occur in a small outcrop of Lissie Gravel near Rio Grande City.

A sandstone and gravel outcrop on a hill south of Mission, known as La Lomita, shows no dominant. There is a dense growth of mixed vegetation which contains a greater variety of plants than is usually found in an equal area in the *mesquital-chaparral.* The following plants are prominent or abundant in this society: *Adelia Vaseyi, Bernardia myricaefolia, Schaefferia cuneifolia, Coursetia axillaris, Acacia amentacea, Prosopis juliflora* var. *glandulosa, Randia aculeata. Coursetia axillaris* is extremely rare, probably occurring nowhere else in the Rio Grande Valley.

The *amargosal* is an area dominated by *Castela Nicholsonii.* This species is particularly abundant in Lissie Gravel near Peñitas and La Joya (pl. XI). Sub-dominants are *Acacia amentacea* and *Zizyphus obtusifolia.* Other plants of importance are *Celtis pallida, Karwinskia Humboldtiana, Schaefferia cuneifolia, Ancistrocactus Scheeri, Dolicothele sphaerica, Echinocereus enneacanthus, E. pentalophus, Hamatocactus setispinus, Homalocephala texensis, Neomammillaria hemisphaerica, N. Heyderi, Opuntia leptocaulis, O. Lindheimeri, O. Schottii, Guaiacum sanctum, and Viguiera stenoloba.*

High dry land included mostly in the Hebbronville Plain is known as the *mesa.* The soil is sandy loam with limestone and

FIGURE 1

FIGURE 2

PLATE XI. Fig. 1. A limestone outcrop. *Mortonia Greggii* (foreground) dominant, with *Leucophyllum frutescens, Cordia Boissieri* and *Acacia Berlandieri* present. Fig. 2. Lake La Joya bordered by a dense growth of *Castela Nicholsonii.* This society is known as *amargosal.*

gravel outcrops. Much of the vegetation is mixed, with no outstanding dominant. The *ebanal* is dominated by *Siderocarpos flexicaulis;* the *nacahuital* by *Cordia Boissieri* and the *comal* by *Bumelia lycioides. Cordia Boissieri* is usually found to prefer limestone and gravel hillsides. *Lippia ligustrina* and *Celtis pallida* are usually prominent here. *Bumelia lycioides* usually occurs on high level land in sandy loam soil, although single specimens are scattered throughout the Rio Grande Valley.

Prosopis juliflora var. *glandulosa* often dominates societies throughout the *mesa,* especially in sandy soil or in lower places between hills or near arroyos. In this *mesquital* the usually prominent species are *Celtis pallida, Opuntia leptocaulis,* and *Opuntia Lindheimeri.* The latter likewise attains dominance in certain localities, often almost excluding other species.

East of the *mesa* and in the western part of the Rio Grande Delta there is a variety of societies largely determined by soil and moisture conditions. Much of the vegetation in this area is mixed, with no outstanding dominant. Prominent plants growing in the Harlingen Clay near San Benito are given below grouped according to layers: (1) lower layer, *Setaria macrostachya, Trichloris pluriflora, Croton Cortesianus, Opuntia Lindheimeri, Salvia coccinea, Parthenium Hysterophorus,* and *Viguiera stenoloba;* (2) upper layer (shrubs 5–8 feet high, mesquites 10–15 feet high) *Celtis pallida, Forestiera angustifolia, Leucophyllum frutescens, Pithecolobium brevifolium, Prosopis juliflora* var. *glandulosa, Bumelia angustifolia, Zizyphus obtusifolia, Opuntia Lindheimeri, Lantana horrida,* and *Heimia salicifolia.*

Acanthocereus pentagonus (pl. XII), commonly called "night-blooming cereus", with the mesquite forms an association within the *mesquital-chaparral* in the vicinity of Rio Hondo. This association is several miles in extent. About four miles east of Rio Hondo the cactus is dominant, climbing in mesquites and forming such a dense tangle that it is almost impossible to get through without a "machete." Farther north, in an open mesquite wood it is frequent with *Spartina Spartinae* and *Opuntia Lindheimeri.* In places where the cactus and mesquite share dominance the following are prominent in the upper layer: *Celtis pallida, Zizyphus obtusifolia, Xanthoxylum Pterota* and *Opuntia Lindheimeri.* The lower layer is composed largely of the following: *Rivina humilis, Malvastrum caromandelianum, Sida paniculata, Heliotropium indicum, Gilia incisa, Hamatocactus setispinus* and *Salvia coccinea.*

Depressions anywhere in the lower part of the Rio Grande Valley in which run-off and flood waters gather often have a growth of *Parkinsonia aculeata* (*retama*). A society dominated by this species is called *retamal. Acacia Farnesiana* is often second in dominance here, and in depressions which are periodically dry it is apt to be dominant. *Typha latifolia, Scirpus Hallii, Atamosco texana* and *Castalia elegans* (pl. XII) are usually present growing

FIGURE 1

FIGURE 2

PLATE XII. Fig. 1. *Acanthocereus pentagonus*. This cactus requires much more water than most species. It extends over an area of several square miles east of Rio Hondo and often stands in water for weeks after a gulf storm without serious injury. Fig. 2. A shallow resaca near Alamo. *Scirpus Hallii* and *Castalia elegans* are shown here. *Parkinsonia aculeata* is in the background.

in the water. Some societies also contain *Echinodorus cordifolius* and *Sagittaria variabilis.*

The *huisachal* is dominated by *Acacia Farnesiana.* Besides the ones mentioned above there are other societies dominated by this species near the Rio Grande. It survives flood water, in which it stands for months, and the soil when drying out often develops deep cracks making conditions difficult for the growth of small plants. *Rumex mexicanus, Hartmannia speciosa, Ambrosia elatior, Parthenium Hysterophorus* and *Aster exilis* are among the first to enter.

The *charco* is a small low area covered with shallow water. *Typha latifolia* is dominant associated with *Cyperus articulatus, Scirpus validus, Marsilia vestita, Naias guadalupensis, Hartmannia speciosa* and *Aster exilis.*

Resacas formed by cut-offs in the old river channel usually contain shallow water. These resacas have practically the same type of vegetation which is found in other depressions. A resaca near Rio Hondo has an abundance of *Ipomea fistulosa* (probably an escape) occurring with the usual dominants. This society is called *amoral.* Aquatics here are *Chara praelonga, Marsilia vestita, M. macropoda, Typha latifolia, Lemna minor, Heteranthera limosa, Eichornia crassipes, Castalia elegans, Utricularia subulata, Radicula Walteri* and sedges (named at end of paper). Wet bank vegetation includes various sedges, *Cynodon Dactylon,* and *Aster exilis. Lepidium virginicum, Hartmannia speciosa, Urtica chamaedryoides* and *Lycopersicon cerasiforme* occur in the moist shady zone.

Irrigation has had some effect on plant distribution. Seeds are carried by the water and become established along the banks. The moisture added to the soil permits the growth of plants ordinarily excluded by dry conditions. The main canals are always filled with water and such species as *Cynodon Dactylon, Holcus halepensis, Paspalum Langei, Commelina longicaulis* and *Parthenium Hysterophorus* grow along the banks. Artificial depressions, locally called "barrow pits" at the sides of the canals, always contain some seepage water, and usually have the following species: *Marsilia vestita, Typha latifolia, Echinodorus cordifolius, Phragmites communis, Cyperus acuminatus, Cyperus oxycarioides, Scirpus validus, Castalia elegans,* and *Jussiaea diffusa.* Some of the smaller canals which carry water only periodically are choked with *Eichornia crassipes. Typha latifolia, Salix longifolia, Celtis pallida,* and *Cynodon Dactylon* also flourish in this environment.

There is a heavily wooded area along the Rio Grande in Cameron County in which trees reach a height of fifty feet or more. Near Alamo in such a situation the upper layer consists of *Celtis mississippiensis, Ulmus crassifolia, Siderocarpos flexicaulis* (pl. XIII), *Sapindus Drummondii* (pl. XIII) and *Fraxinus Berlandieri.* These trees are festooned with *Tillandsia usneoides. Tillandsia recurvata* and *Tillandsia Baileyi* are also present. Promi-

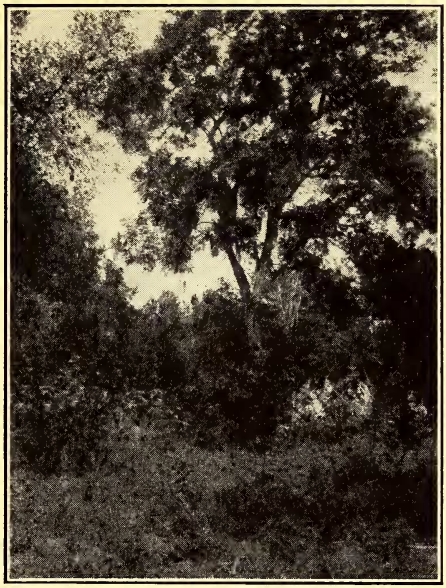

FIGURE 1

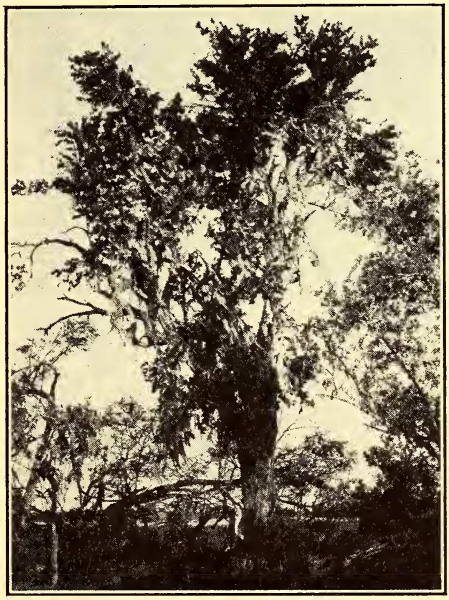

FIGURE 2

PLATE XIII. Fig. 1. Wooded area near the Rio Grande, Alamo. The large tree is *Sapindus Drummondii*. Fig. 2. *Siderocarpos flexicaulis* in woods near the Rio Grande, Alamo. This same species is a small shrub in dry areas.

nent species in the middle layer are *Celtis pallida, Zizyphus obtusifolia, Porlieria angustifolia, Malphigia glabra, Diospyros texana* and *Bumelia angustifolia.* The lower layer is a tangle of vines and weak-stemmed, herbaceous plants. The most prominent ones are *Rivina humilis, Clematis Drummondii, Urtica chamaedryoides, Cuscuta indecora, Cardiospermum Halicacabum, Plumbago scandens, Capsicum baccatum* and *Monarda dispersa* (pl. XIV).

Flood waters disturb and destroy the smaller vegetation along the river leaving stretches of deep sand. These stretches are soon covered by almost pure stands of *Baccharis* which are often swept away before being replaced by other species.

A single specimen of *Taxodium mucronatum* stands in the woods south of Havana. The tree is approximately forty feet tall. Mexican residents report that it has been there for at least a hundred years. Emory (17) states that cypress was found near the mouth of the Rio Salado, which is a tributary of the Rio Grande, and expressed the hope that some future day this species would spread down the river, furnishing building material for inhabitants.

II. The Chaparral Climax

The Bordas Scarp and a strip along the Rio Grande between Roma and San Ignacio is covered with a low shrubby growth which seems fairly stable. There are societies of mesquite on flats and along arroyos, but in general the hilly broken territory known as the "Breaks of the Rio Grande" is a distinct *chaparral,* as the term is used in this paper. *Acacia amentacea* is probably a general dominant with subdominants varying with the locality. Some of the most outstanding associations, societies and communities are given below.

Cenizal. This association is dominated by *Leucophyllum frutescens* with subdominants *Acacia amentacea* and *Acacia Berlandieri.* The presence of *Leucophyllum* usually indicates a limestone outcrop, and *Acacia Berlandieri* is often found on gravel hills. A *cenizal* occurs about two miles west of Roma and is several miles in extent (pl. X). The following plants were collected in this area: *Ephedra antisiphilitica, Atriplex acanthocarpa, Bouteloua barbata, B. trifida, Cenchrus pauciflorus, Pappophorum mucronulatum, Talinum angustissimum, Acacia Berlandieri, A. amentacea, Parosela nana, Croton ciliato-glandulosus, C. fruticulosus, Jatropha spathulata, Schaefferia cuneifolia, Karwinskia Humboldtiana, Microrhamnus ericoides, Abutilon incanum, Gayoides crispum, Sida filipes, Ancistrocactus Scheeri, Hamatocactus setispinus, Echinocereus enneacanthus, Neomammillaria hemisphaerica, Opuntia leptocaulis, O. Lindheimeri, Heliotropium confertifolium, Marilaunidium hispidum, Goniostachyum citrosum, Nicotiana repanda, Leucophyllum frutescens, Actinea odorata.*

Barettal. This occurs on gravel and limestone hills. The dominant species is *Helietta parvifolia* (pl. XIV). It is a rather

FIGURE 1

FIGURE 2

PLATE XIV. Fig. 1. A society of *Monarda dispersa* in a mesquite wood, Havana. Fig. 2. *Helietta parvifolia* on a low hill east of Rio Grande City.

large community extending over several hills east of Rio Grande City. A few scattering plants are found as far east as Peñitas, and some grow in the region of the petrified forest east of Roma. Other prominent plants in this community are as follows: *Bouteloua barbata, Setaria macrostachya, Agave Lechuguilla, Acacia amentacea, Cercidium floridum, Castela Nicholsonii, Koeberlinia spinosa, Ancistrocactus Scheeri, Coryphantha Runyonii, Opuntia leptocaulis, O. Lindheimeri, Thelocactus bicolor, Coldenia canescens, Cordia Boissieri, Lippia ligustrina. Agave Lechuguilla* is not abundant but is worthy of mention as this locality seems to be the eastern limit of its range. A new species, *Coryphantha Pirtleana,* was recently found here by Pirtle brothers of Alamo.

Hechtia Texensis Society. The soil may be somewhat saline since *Varilla texana,* which is a halophyte (14), is always present. Burros enjoy eating the succulent flower stalks of *Hechtia,* many of which are prevented from seeding by being nipped off early. New plants are produced at the base of the parent plant, forming large mounds so dense that no other species can gain a foothold (pl. XV). Some of the plants besides *Varilla* that are commonly found with *Hechtia* are *Panicum Hallii, Zizyphus obtusifolia, Sida filipes, Schaefferia cuneifolia, Jatropha spathulata, Porlieria angustifolia, Pappophorum bicolor, Echinocereus enneacanthus,* and *Opuntia Lindheimeri.*

Agave Society. This society occurs on sandy loam and limestone hills. Agaves are found in only a few localities in the two upper counties. Probably the largest group is five miles south of Zapata. The vegetation growing with this species is characteristic of that found in much of the *chaparral* (pl. XV).

Bordas Scarp Vegetation. The approach to the Bordas Scarp is a gentle slope toward the west. The vegetation is of the *mesquital-chaparral* type, changing to the lower, sparse *chaparral* found on gravel. An area about a mile in length was chosen as representative of the *chaparral* of the escarpment. An interesting cactus, *Astrophytum asterias,* is found here, which, as far as known, occurs nowhere else in the United States (9). The following species were collected in this locality: *Ephedra antisiphilitica, Aristida purpurea, Chloris cucullata, Eragrostis curtipedicellata, Yucca* sp., *Runyonia longiflora, Celtis pallida, Talinopsis frutescens, Acacia amentacea, Prosopis juliflora* var. *glandulosa, Jatropha spathulata, Schaefferia cuneifolia, Karwinskia Humboldtiana, Zizyphus obtusifolia, Koeberlinia spinosa, Menodora heterophylla, Astrophytum asterias, Coryphantha Runyonii, Dolicothele sphaerica, Echinocereus enneacanthus, E. Fitchii, E. pentalophus, Hamatocactus setispinus, Lophophora Williamsii* (pl. XVI), *Neomammillaria hemisphaerica, N. Heyderi, Opuntia leptocaulis, O. Lindheimeri, Thelocactus bicolor, Wilcoxia Poselgeri, Lippia macrostachya, Ibervillea Lindheimeri, Varilla texana, Verbesina encelioides, Zinnia pumila.* The following plants were found at the base of the escarpment: *Triodia mutica,*

FIGURE 1

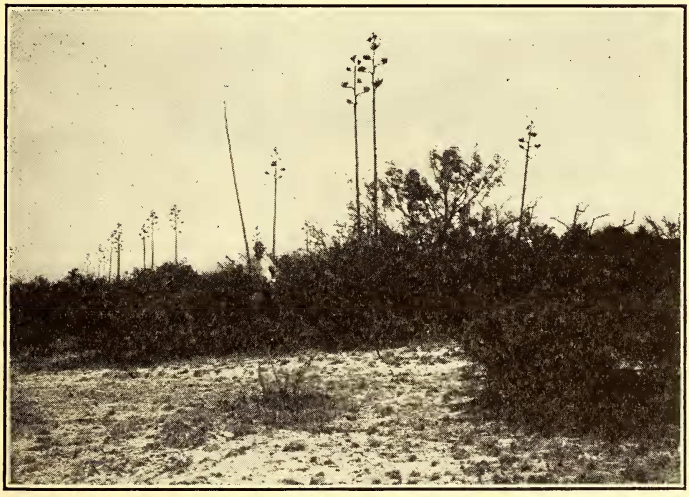

FIGURE 2

PLATE XV. Fig. 1. A society of *Hechtia texensis* near an arroyo between Roma and Zapata. Fig. 2. *Agave melliflua* in flower. This society occurs in a mixed *chaparral* near Zapata.

Sporobolus Wrightii, Rivina humilis, Jatropha Berlandieri, Abutilon Wrightii, Amoreuxia Wrightii, Aphanostephus skirrobasis var. *Halli, Dyssodia tephroleuca, Simsia calva, Zexemenia hispida.*

Costillal. The distribution of this society is mostly in Zapata County. The dominant is *Microrhamnus ericoides.* In places this species is so dense as to almost crowd out competitors. Low mesquites, *Zizyphus obtusifolia* and *Colubrina texensis* are frequently associated with it.

Palo Verde Society. The dominant species are *Cercidium texanum* in the region of Zapata, and *Cercidium floridum* near Peñitas. These species usually occur on dry mesas in open brushland. They thrive in dry gravel soil as the leaves are early deciduous and the stems carry on photosynthesis. *Bouteloua barbata, B. trifida, Coldenia canescens, Heliotropium confertifolium, Parthenium Hysterophorus* are some of the herbaceous species commonly associated with *Cercidium.* The shrubs of this society vary with the locality.

Gobernadoral. The dominant, *Covillea tridentata,* has invaded northern Zapata County from the northwest. The fact that it is most abundant on very dry and unproductive soil might give the impression that it prefers that habitat, but it does not. *Covillea* is easily crowded out by other vegetation in more favorable situations. Spaulding (32) states that it is capable of adapting itself to desert conditions by reducing leaf surface and by abstracting water from very dry soil, but it is capable of living and does live as an ordinary mesophyte if a suitable supply of water is available.

Vegetation along Arroyos. Shrubs inhabiting areas cut by arroyos are often larger near the banks where water stands after a storm. Species such as *Acacia Farnesiana* and *Parkinsonia aculeata* grow near these water-holes. *Cynodon Dactylon, Pappophorum bicolor, P. mucronulatum, Sporobolus argutus, Trichloris mendocina, Triodia pilosa, Panicum Hallii, Lepachys columnaris* var. *pulcherrima, Nicotiana longiflora, Parosela nana, Verbesina encelioides,* and *Chamaesyce laredana* are plants growing in dry arroyo beds. At Arroyo Loma Blanca *Ferocactus hamatacanthus* (pl. XVI) is abundant. One plant has persisted in the crotch of a tree for at least four years in spite of the fact that water has washed away all the soil in which it originally grew. *Echinocereus enneacanthus,* the species of cactus which has a greater distribution than any other in the Lower Rio Grande excepting the opuntias, often grows to the very edge of arroyos.

There are other societies in the chaparral which may also be found in the *mesquital-chaparral* phase. *Bumelia lycioides* and *B. angustifolia* occur in societies, clans and families throughout the area. Such plant groups are known as *comales* (singular, *comal*). *Diospyros texana* forms a *zapotal,* and *Yucca* a *pital.* There are few areas in which *Yucca* grows abundantly. It is usually scattered singly or in very small groups.

(*To be concluded*)